CLAIMS

What is claimed is:

1. A liquid crystal display system comprising:

(a) a liquid crystal display comprising:

(a1) a liquid crystal material;

(a2) a first orientation layer to impart a first orientation direction to a first region of the liquid crystal material; and

(a3) a second orientation layer to impart a second orientation direction to a second region of the liquid crystal material;

(b) a light source;

(c) a viewing display optically coupled to receive light from the liquid crystal display; and

(d) wherein:

(d1) the liquid crystal display is optically coupled to the light source and is operable to receive incoming light, wherein the incoming light is polarized and has a polarization direction relative to the liquid crystal display; and

(d2) the first orientation direction and the second orientation direction are each rotationally offset from an optical mode of the liquid crystal display in which the polarization direction of the incoming light bisects a twist angle defined by the first orientation direction and the second orientation direction.

2. The liquid crystal display system of claim 1 wherein the liquid crystal display is a first liquid crystal display and the polarization direction is a first polarization direction, and further comprising:

(a) a second liquid crystal display comprising:

(a1) a liquid crystal material;

(a2) a first orientation layer to impart a first orientation direction to a first region of the liquid crystal material; and

(a3) a second orientation layer to impart a second orientation direction to a second region of the liquid crystal material; and

(b) wherein:

(b1) the first liquid crystal display is adapted to receive a first color light component;

(b2) the second liquid crystal display is optically coupled to the light source and is adapted to receive a second color light component;

(b3) the second color light component has a second polarization direction relative to the second liquid crystal display that is substantially the same as the first polarization direction relative to the first liquid crystal display;

(b4) the viewing display is further optically coupled to receive at least a portion of the second color light component from the second liquid crystal display; and

(b5) the first orientation direction and the second orientation direction of the second liquid crystal display are each rotationally offset from an optical mode of the second liquid crystal display in which the second polarization direction bisects a second twist angle defined by the first orientation direction and the second orientation direction of the second liquid crystal display.

3. The liquid crystal display system of claim 2 further comprising a color splitter, optically coupled between the light source and the first and second liquid crystal displays, to selectively provide the first color light component and the second color light component.

4. The liquid crystal display system of claim 3 further comprising a polarizing beam splitter optically coupled between the light source and the color

splitter, wherein the polarizing beam splitter provides light comprising the first color component and the second color component in a polarized form.

5. The liquid crystal display system of claim 2 further comprising:

(a) a third liquid crystal display comprising:

(a1) a liquid crystal material;

(a2) a first orientation layer to impart a first orientation direction to a first region of the liquid crystal material; and

(a3) a second orientation layer to impart a second orientation direction to a second region of the liquid crystal material; and

(b) wherein:

(b1) the third liquid crystal display is optically coupled to the light source and is adapted to receive a third color light component;

(b2) the third color light component has a third polarization direction relative to the third liquid crystal display that is substantially the same as the first polarization direction relative to the first liquid crystal display;

(b3) the viewing display is further optically coupled to receive at least a portion of the third color light component from the third liquid crystal display; and

(b4) the first orientation direction and the second orientation direction of the third liquid crystal display are each rotationally offset from an optical mode of the third liquid crystal display in which the polarization direction bisects a third twist angle defined by the first orientation direction and the second orientation direction of the third liquid crystal display.

6. The liquid crystal display system of claim 5 wherein:

the first orientation direction and the second orientation direction of the first liquid crystal display are each rotationally offset by a first offset angle;

the first orientation direction and the second orientation direction of the second liquid crystal display are each rotationally offset by a second offset angle;

the first color light component corresponds to red light;

the second color light component corresponds to green light;

the first offset angle is greater than the second offset angle;

the first orientation direction and the second orientation direction of the third liquid crystal display are each rotationally offset by a third offset angle;

the third color light component corresponds to blue light; and

the third offset angle is between the first offset angle and the second offset angle.

7. The liquid crystal display system of claim 2 wherein:

the first orientation direction and the second orientation direction of the first liquid crystal display are each rotationally offset by a first offset angle;

the first orientation direction and the second orientation direction of the second liquid crystal display are each rotationally offset by a second offset angle;

the first offset angle corresponds to a substantial optimization of photopic contrast for a first wavelength range of light corresponding to the first color light component; and

the second offset angle corresponds to a substantial optimization of photopic contrast for a second wavelength range of light corresponding to the second color light component.

8. The liquid crystal display system of claim 2 wherein:

the first orientation direction and the second orientation direction of the first liquid crystal display are each rotationally offset by a first offset angle;

the first orientation direction and the second orientation direction of the second liquid crystal display are each rotationally offset by a second offset angle;

the first and second orientation layers of the first liquid crystal display are rubbed to provide the first offset angle;

the first and second orientation layers of the second liquid crystal display are rubbed to provide the second offset angle; and

the first offset angle and second offset angle are different.

9. The liquid crystal display system of claim 8 wherein the first and second offset angles are different by at least about 0.5 degrees.

10. The liquid crystal display system of claim 2 wherein:

the first orientation direction and the second orientation direction of the first liquid crystal display are each rotationally offset by a first offset angle;

the first orientation direction and the second orientation direction of the second liquid crystal display are each rotationally offset by a second offset angle;

the first color light component corresponds to red light;

the second color light component corresponds to green light; and

the first offset angle is greater than the second offset angle.

11. The liquid crystal display system of claim 1 wherein the first orientation direction and the second orientation direction are each rotationally offset by substantially the same rotational angle.

12. The liquid crystal display system of claim 11 wherein the rotational angle is greater than about 0.5 degrees and less than about 10 degrees.

13. The liquid crystal display system of claim 11 wherein the rotational angle is less than about 5 degrees.

14. The liquid crystal display system of claim 1 wherein the first orientation direction and the second orientation direction are offset sufficiently to improve a photopic contrast, provided by the liquid crystal display, relative to the optical mode.

15. The liquid crystal display system of claim 1 wherein the first orientation direction and the second orientation direction are offset by slight rotational angles.

16. The liquid crystal display system of claim 1 wherein the first orientation direction and the second orientation direction are rotationally offset by rotating the liquid crystal display by an offset rotational angle relative to the polarization direction.

17. The liquid crystal display system of claim 1 wherein:

the first orientation layer is formed by rubbing at a first rubbing angle;

the second orientation layer is formed by rubbing at a second rubbing angle; and

the first orientation direction and the second orientation direction are rotationally offset by offsetting the first and second rubbing angles by an offset rotational angle.

18. The liquid crystal display system of claim 2 further comprising a polarizing beam splitter optically coupled between the light source and the first liquid crystal display, wherein the polarizing beam splitter is operable to provide polarized light comprising the first color light component to the first liquid crystal display .

19. The liquid crystal display system of claim 18 wherein the polarizing beam splitter selectively provides the polarized light as an S-component of light.

20. The liquid crystal display system of claim 18 further comprising a color splitter optically coupled between the polarizing beam splitter and the first liquid crystal display for selectively providing the first color light component.

21. The liquid crystal display system of claim 1 wherein the liquid crystal display is a twisted nematic liquid crystal display.

22. The liquid crystal display system of claim 1 wherein the viewing display is a screen for an projected image or is a viewer for direct viewing by a user.

23. The liquid crystal display system of claim 1 wherein the first and second orientation directions are sufficiently rotationally offset to provide a dark state reflectivity peak amplitude reduction for the liquid crystal display of at least about 25 percent relative to the optical mode.

24. The liquid crystal display system of claim 1 wherein the first and second orientation directions are sufficiently rotationally offset to provide a dark state reflectivity peak amplitude reduction for the liquid crystal display of at least about 35 percent relative to the optical mode.

25. The liquid crystal display system of claim 1 wherein the first and second orientation directions are sufficiently rotationally offset to provide a dark state reflectivity peak amplitude reduction for the liquid crystal display of between about 25 to 85 percent relative to the optical mode.

26. The liquid crystal display system of claim 1 wherein the first and second orientation directions are sufficiently rotationally offset to provide a dark state reflectivity peak amplitude reduction for the liquid crystal display of between about 35 to 50 percent relative to the optical mode.

27. A display kit comprising a liquid crystal display adapted to receive incoming linearly-polarized light, wherein the liquid crystal display comprises:

a pixel array wherein the incoming linearly-polarized light has a first polarization direction relative to the pixel array;

a liquid crystal material;

a first orientation layer to impart a first orientation direction to a first region of the liquid crystal material;

a second orientation layer to impart a second orientation direction to a second region of the liquid crystal material; and

wherein:

(i) the liquid crystal material is disposed between the first orientation layer and the second orientation layer; and

(ii) the first orientation direction and the second orientation direction are each rotationally offset by a first offset angle from an optical mode of the liquid crystal display in which the polarization direction bisects a first twist angle defined by the first orientation direction and the second orientation direction.

28. The display kit of claim 27 wherein the liquid crystal display is a first liquid crystal display and the polarization direction is a first polarization direction, and further comprising:

(a) a second liquid crystal display adapted to receive incoming linearly-polarized light having a second polarization direction, wherein the second liquid crystal display comprises:

(a1) a pixel array wherein the second polarization direction relative to the pixel array of the second liquid crystal display is substantially the same as the first polarization direction relative to the pixel array of the first liquid crystal display;

(a2) a liquid crystal material;

(a3) a first orientation layer to impart a first orientation direction to a first region of the liquid crystal material;

(a4) a second orientation layer to impart a second orientation direction to a second region of the liquid crystal material; and

(a5) wherein:

(i) the liquid crystal material is disposed between the first orientation layer and the second orientation layer; and

(ii) the first orientation direction and the second orientation direction are each rotationally offset by a second offset angle from an optical mode of the second liquid crystal display in which the second polarization direction bisects a second twist angle defined by the first orientation direction and the second orientation direction of the second liquid crystal display; and

(b) wherein:

(b1) the first liquid crystal display is adapted to provide a first color light component for forming an image on a display;

(b2) the second liquid crystal display is adapted to provide a second color light component for forming the image; and

(b3) the first liquid crystal display and the second liquid crystal display are adapted to cooperate in forming the image.

29. The display kit of claim 28 further comprising:

(a) a third liquid crystal display adapted to receive incoming linearly-polarized light having a third polarization direction, wherein the third liquid crystal display comprises:

(a1) a pixel array wherein the third polarization direction relative to the pixel array of the third liquid crystal display is substantially the same as the first polarization direction relative to the pixel array of the first liquid crystal display;

(a2) a liquid crystal material;

(a3) a first orientation layer to impart a first orientation direction to a first region of the liquid crystal material;

(a4) a second orientation layer to impart a second orientation direction to a second region of the liquid crystal material; and

(a5) wherein:

(i) the liquid crystal material is disposed between the first orientation layer and the second orientation layer; and

(ii) the first orientation direction and the second orientation direction are each rotationally offset by a third offset angle from an optical mode of the third liquid crystal display in which the third polarization direction bisects a third twist angle defined by the first orientation direction and the second orientation direction of the third liquid crystal display; and

(b) wherein:

(b1) the third liquid crystal display is adapted to provide a third color light component for forming the image; and

(b2) the first liquid crystal display, the second liquid crystal display, and the third liquid crystal display are adapted to cooperate in forming the image.

30. The display kit of claim 27 wherein the liquid crystal display further comprises:

a reflective layer underlying the second orientation layer; and

a dielectric layer disposed between the reflective layer and the second orientation layer.

31. The display kit of claim 30 wherein the reflective layer comprises aluminum.

32. The display kit of claim 30 wherein the dielectric layer comprises at least one compound selected from the group consisting of a silicon nitride and a silicon oxide.

33. The display kit of claim 32 wherein the silicon oxide is silicon dioxide.

34. The display kit of claim 32 wherein the liquid crystal display further comprises a silicon substrate underlying the reflective layer.

35. The display kit of claim 30 wherein the first and second orientation layers comprise a polyimide material.

36. A method of manufacturing a liquid crystal display system comprising a first liquid crystal display, having a first twist angle, for receiving a first color light component having a first polarization direction relative to the first liquid crystal display and a second liquid crystal display, having a second twist angle, for receiving a second color light component that is substantially complementary to the first color light component and has a second polarization direction relative to the second liquid crystal display substantially the same as the first polarization direction relative to the first liquid crystal display, the method comprising:

forming the first liquid crystal display to have a first offset angle relative to an optical mode of the first liquid crystal display in which the first polarization direction bisects the first twist angle, wherein the first offset angle is adjusted to improve photopic contrast for the first color light component; and

forming the second liquid crystal display to have a second offset angle relative to an optical mode of the second liquid crystal display in which the second polarization direction bisects the second twist angle, wherein the second offset angle is adjusted to improve photopic contrast for the second color light component.

37. The method of claim 36 wherein the first liquid crystal display comprises first and second orientation layers, corresponding to respective first and second orientation directions, surrounding a liquid crystal material and the method further comprises rubbing the first and second orientation layers with a rotational offset from the first and second orientation directions to provide the first and second offset angles.

38. The method of claim 37 wherein:

the first liquid crystal display is formed as one of many displays on a first semiconductor wafer, wherein all displays on the first semiconductor wafer are formed with the first offset angle; and

the second liquid crystal display is formed as one of many displays on a second semiconductor wafer, wherein all displays on the second semiconductor wafer are formed with the second offset angle.

39. The method of claim 36 further comprising:

selecting the first offset angle to provide a substantially optimized photopic contrast relative to the optical mode of the first liquid crystal display; and

selecting the second offset angle to provide a substantially optimized photopic contrast relative to the optical mode of the second liquid crystal display.

40. The method of claim 39 further comprising:

selecting a first photopic contrast minimum value for the first color light component; and

adjusting a first on state voltage and the first offset angle for the first liquid crystal display to provide a photopic contrast for the first color light component that is equal to or greater than the first photopic contrast minimum standard.

41. The method of claim 40 further comprising:

selecting a second photopic contrast minimum value for the second color light component; and

adjusting a second on state voltage and the second offset angle for the second liquid crystal display to provide a photopic contrast for the second color light component that is equal to or greater than the second photopic contrast minimum standard.

42. A liquid crystal display system comprising:

(a) a liquid crystal display comprising:

(a1) a liquid crystal material;

(a2) a first orientation layer to impart a first orientation direction to a first region of the liquid crystal material; and

(a3) a second orientation layer to impart a second orientation direction to a second region of the liquid crystal material;

(b) a light source;

(c) a viewing display optically coupled to receive light from the liquid crystal display; and

(d) wherein:

(d1) the liquid crystal display is optically coupled to the light source and is operable to receive incoming light, wherein the incoming light is polarized and has a polarization direction relative to the liquid crystal display; and

(d2) the first orientation direction and the second orientation direction are each rotationally offset relative to the polarization direction of the incoming light to improve photopic contrast.

43. The liquid crystal display system of claim 42 wherein the first orientation direction and the second orientation direction are each rotationally offset by less than about 10 degrees.

44. A liquid crystal display system comprising:

(a) a liquid crystal display comprising:

(a1) a liquid crystal material;

(a2) a first orientation layer to impart a first orientation direction to a first region of the liquid crystal material; and

(a3) a second orientation layer to impart a second orientation direction to a second region of the liquid crystal material;

(b) a light source;

(c) a viewing display optically coupled to receive light from the liquid crystal display; and

(d) wherein:

(d1) the liquid crystal display is optically coupled to the light source and is operable to receive incoming light, wherein the incoming light is polarized and has a polarization direction relative to the liquid crystal display; and

(d2) the first orientation direction and the second orientation direction are each rotationally offset from an optical mode of the liquid crystal display in which the polarization direction of the incoming light divides a twist angle defined by the first orientation direction and the second orientation direction.

45. The liquid crystal display system of claim 44 wherein the first orientation direction and the second orientation direction are each rotationally offset by less than about 10 degrees.